

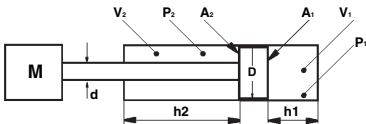
Criteria for sizing of cylinders and electrohydraulic servocylinders

1 STATIC AND DYNAMIC CONTROLS

For all working conditions, check the static characteristics and the combined bending and compressing stress as shown in section [4]. Theoretical check of the dynamic limits of the system should always be carried out up to what shown at point [6], after all functional characteristics of the system itself have been defined. When determining the forces acting on the system, consider the forces of inertia and the external friction forces and the counterpressures generated by effect of cushioning and restrictor valves of the hydraulic circuit. For an overall check of the system an analysis should always be carried out by the Atos technical office, especially where high acceleration and/or short cycle times are requested.

2 SYMBOLS, DIAGRAMS AND BASIC FORMULA

Single rod cylinders



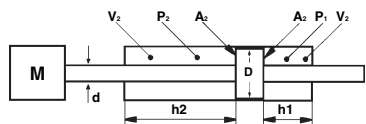
Cylinder speed during rod extension
 $V_1 = \frac{10 \cdot Q}{A_1 \cdot 60} \left[\frac{m}{sec} \right]$

force applied during rod extension
 $F = (p_1 \cdot A_1 - p_2 \cdot A_2) \cdot 10 \text{ [N]}$

Cylinder speed during rod retraction
 $V_2 = \frac{10 \cdot Q}{A_2 \cdot 60} \left[\frac{m}{sec} \right]$

Force applied during rod retraction
 $F = (p_2 \cdot A_2 - p_1 \cdot A_1) \cdot 10 \text{ [N]}$

Double rod cylinders



Cylinder speed during rod
 $V = \frac{10 \cdot Q}{A_2 \cdot 60} \left[\frac{m}{sec} \right]$

Force applied
 $F = (p_2 \cdot p_2) \cdot A_2 \cdot 10 \text{ [N]}$

where: $A_1 = \frac{\pi \cdot D^2}{4 \cdot 100} \text{ [cm}^2\text{]}$ $A_2 = \frac{\pi \cdot (D^2 - d^2)}{4 \cdot 100} \text{ [cm}^2\text{]}$

Quantity	Unit	Symbol
Total force (1)	N	F
Pressure	bar	p
Section	cm ²	A
Bore diameter	mm	D
Rod diameter	mm	d
Cylinder stroke	mm	h
Flow rate	l/min	Q
Speed	m/sec	V
Acceleration	m/sec ²	a
Load mass	Kg	M

(1) The total force is the algebraic sum of all the forces acting on the cylinder:
 Forces of inertia = $F_i = M \cdot a$
 Working forces = F_l
 Friction forces = F_a
 Weight(only for vertical loads) = P

3 SIZING

The table below reports the thrust/retracting sections of the different size combinations rod/piston.

Piston [mm]	25	32	40	50	63	80	100	125	140	160	180	200	250	320	400
Extension section A1-[cm ²]	4,9	8,0	12,6	19,6	31,2	50,3	78,5	122,7	153,9	201,1	254,5	314,2	490,9	804,2	1256,6
Rod [mm]	12 18 14 22 18 22 28 22 28 36 28 36 45 36 45 56 45 56 70 56 70 90 90 70 90 110 110 90 140 140 180 180 220 220 280														
Retraction section A2-[cm ²]	3,8 2,4 6,5 4,2 10,0 8,8 6,4 15,8 13,5 9,6 25,0 21,0 15,3 40,1 34,4 25,6 62,6 53,9 40,1 98,1 84,2 59,1 90,3 162,6 137,4 106,0 159,4 250,5 160,2 336,9 236,4 594,8 424,1 876,5 640,9														

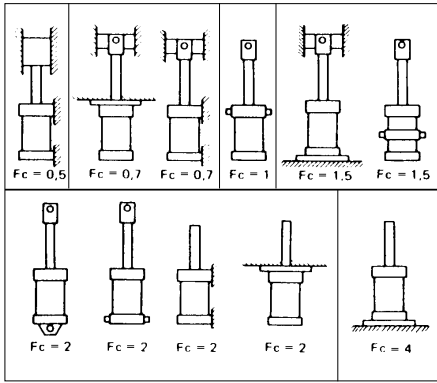
The rod/piston size, based on the system parameters (force, speed, flow) is determined with the formulae reported in section [2] and with the figures obtained from this table. Calculation can be checked also graphically with the nomographs of table P003. The rod dimension must be checked at max. load, according to what reported in section [4].

4 CHECK OF COMBINED BENDING AND COMPRESSING PRESS

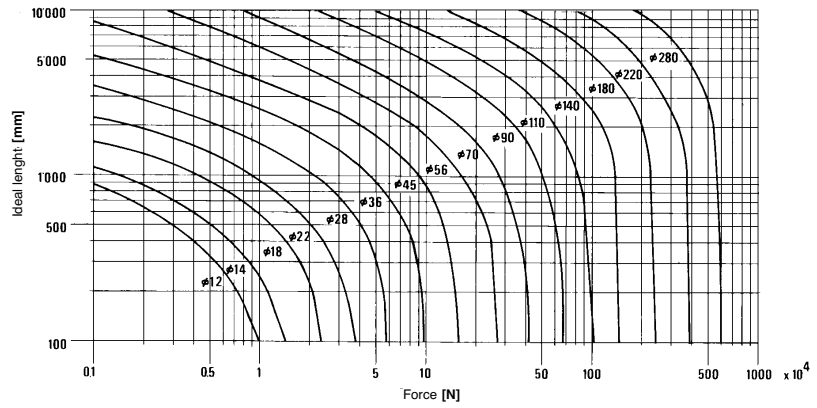
This check is made considering the fully open cylinder as a bar of the same diameter of the rod (safety criteria):

- depending on the data for the mechanical fastening of the cylinder to the structure, obtain the "Fc stroke factor" from table 4.1.
- calculate the "ideal length" multiplying the factor Fc by the cylinder stroke (mm): $L_i = c \times F_c$.
- obtain on diagram 4.2 the point of intersection between the L_i ideal length value and the max. extension value (in N) of the cylinder.
- the rod satisfying the check at max. load is the one corresponding to the curve immediately higher than the intersection point found on diagram 4.2.

4.1 Fc stroke factor



4.2 Checking diagram

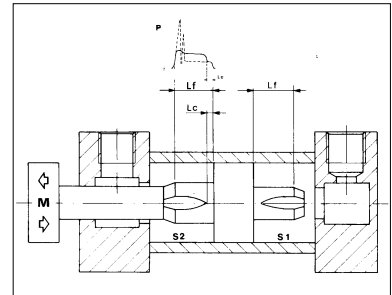


5 STROKE-END CUSHIONING

Stroke-end cushioning is always recommended for speeds exceeding 0.1 m/s, and for applications with vertical loads. Stroke-end cushioning may serve as safety function when the control equipment is out of service, for example in case of servosystems. The table below shows the cushioning lengths Lf and the cushioning sections for each piston and rod diameters of cylinder series CK/CH (ISO 6020-2). For the other series consult Atos technical office.

Ø piston [mm]	25		32		40			50			63			80			100			125			160			200		
Ø Rod [mm]	12	18	14	22	18	22	28	22	28	36	28	36	45	36	45	56	45	56	70	56	70	90	70	90	110	90	140	
Cushioning length Lf [mm]	20		20		29			30			30			30			32			32			40			46		
Cushioning section [cm ²] → S1	4,5		7,4		11,9			18,5			29,1			46,4			73,2			114,0			189,0			294,0		
Cushioning section [cm ²] ← S2	3,58	2,07	6	3,89	8,7	5,49	5,49	14,3	8,2	8,2	19,8	13,8	13,8	32	23,8	23,8	53	37,8	37,8	82	56	56	134	102	102	243	151	

N.B.: For cylinders with transducer the area S1 is significantly reduced. Consult Atos technical office for the values relating to the masses which can be damped, for the various working conditions and for further information.



Cushioning chamber pressure trends for Atos gradual cushioning compared with stepped cushioning, now obsolete

Mass with stroke-end cushioning able to damp

$$M = \frac{(p_1 S - p_2 A) 2 \cdot L_f}{V_0^2} \cdot 10^{-2} \text{ [Kg]} \quad \text{where:}$$

p₁ = supply pressure [bar]
 p₂ = 250 [bar]
 V₀ = working speed [m/s]
 S = cushioning section [cm²]
 L_f = cushioning length [mm]

Calculation is approximately valid and takes into account a max. overpressure of 250 bar in the cushioning section. The formula comes from an elaboration of experimental results. It is not absolute and differences between practical results and theoretical determination are always possible. Atos does not assume responsibility for the use of these formulae in the determination of masses able to damp from cylinders with stroke-end cushioning.

6 DYNAMIC LIMITS IN THE APPLICATION OF HYDRAULIC CYLINDERS

The calculation of pulsing value ω₀ of the cylinder-mass system allows the calculation of the minimum acceleration/deceleration time, the max. speed and the min. space of acceleration/deceleration, without altering the functional stability of the system.

System pulsation value ω₀

$$\omega_0 = \sqrt{\frac{40 \cdot E \cdot A_1}{c \cdot M}} \cdot \frac{1 + \sqrt{\alpha}}{2} \text{ [rad/sec]} \quad \text{where:}$$

E = oil modulus of elasticity (1.4 · 10⁷ kg/cm·s²)
 c = stroke [mm]
 M = mass [kg]
 A₁ = piston section [cm²]
 α = A₂/A₁ annular/piston cross section ratio

Minimum acceleration time, see fig. 6.1

$$t_{\min} = \frac{35}{\omega_0} \text{ [s]}$$

Maximum speed, see fig. 6.1

$$V_{\max} = \frac{S_{\text{tot}}}{t_{\text{tot}} - t_{\min}} \text{ [mm/s]} \quad \text{where: } S_{\text{tot}} = \text{total space to run [mm]} \\ t_{\text{tot}} = \text{total time at disposal [s]}$$

The formula is valid considering a constant acceleration value during t_{min}

Acceleration/deceleration minimum space

$$S_{\min} = \frac{V_{\max} \cdot t_{\min}}{2} \text{ [mm]}$$

The ω₀, and t_{min} values and so the V_{max} and S_{min} values are calculated in conservative way

6.1 Positioning cycle

